



## Supplemental Material

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## Supplemental Material

This document includes a series of figures to supplement those in the manuscript so an interested reader can: 1) verify that the results shown with MERRA-2 are not specific to that model, 2) examine the impact of cyclone characteristics on total precipitation rather than frequency or intensity that are the focus of the manuscript, 3) visualize the additional tests that are mentioned in the manuscript.

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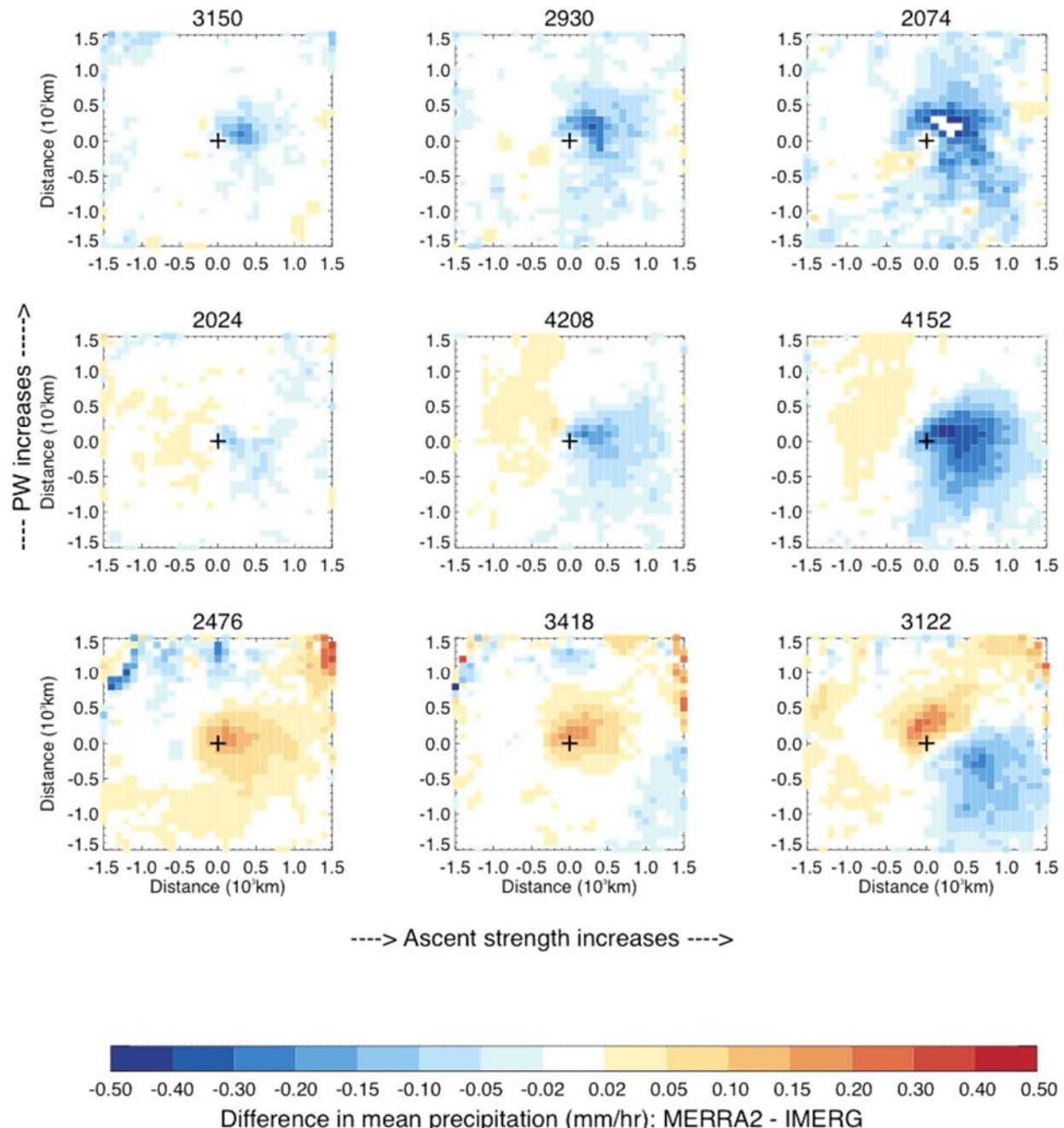
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# 1) PW-ascent strength difference figures

## 1.1 MERRA-2: total precipitation



*Figure 1: Cyclone centered composites of the difference in mean precipitation between MERRA-2 and IMERG as a function of cyclone ascent strength (left to right) and cyclone-wide mean PW (bottom to top). The number at the top of each plot is the total number of cyclones per category for MERRA-2.*

## 1.2 CAM6: total precipitation and intensity

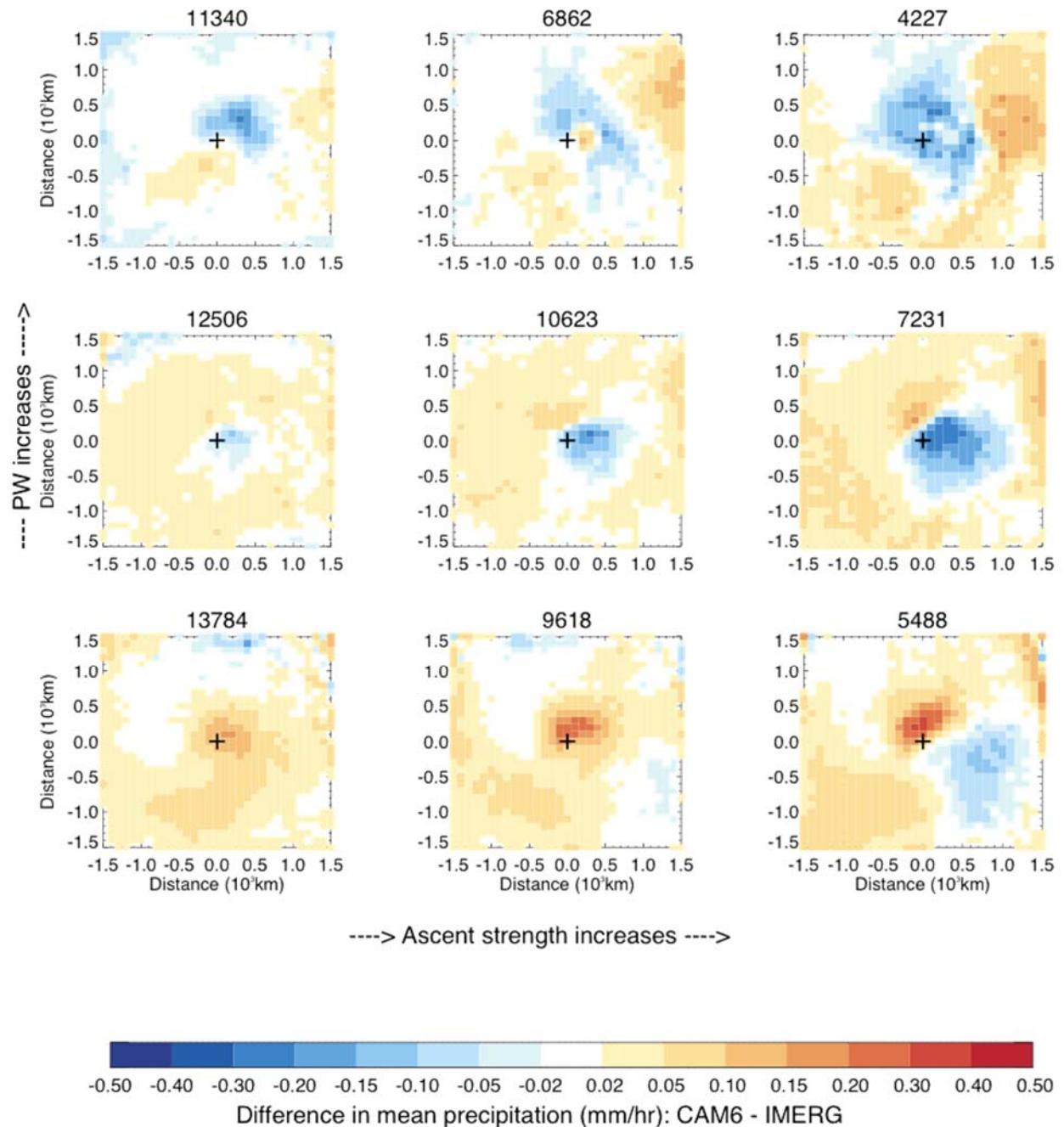
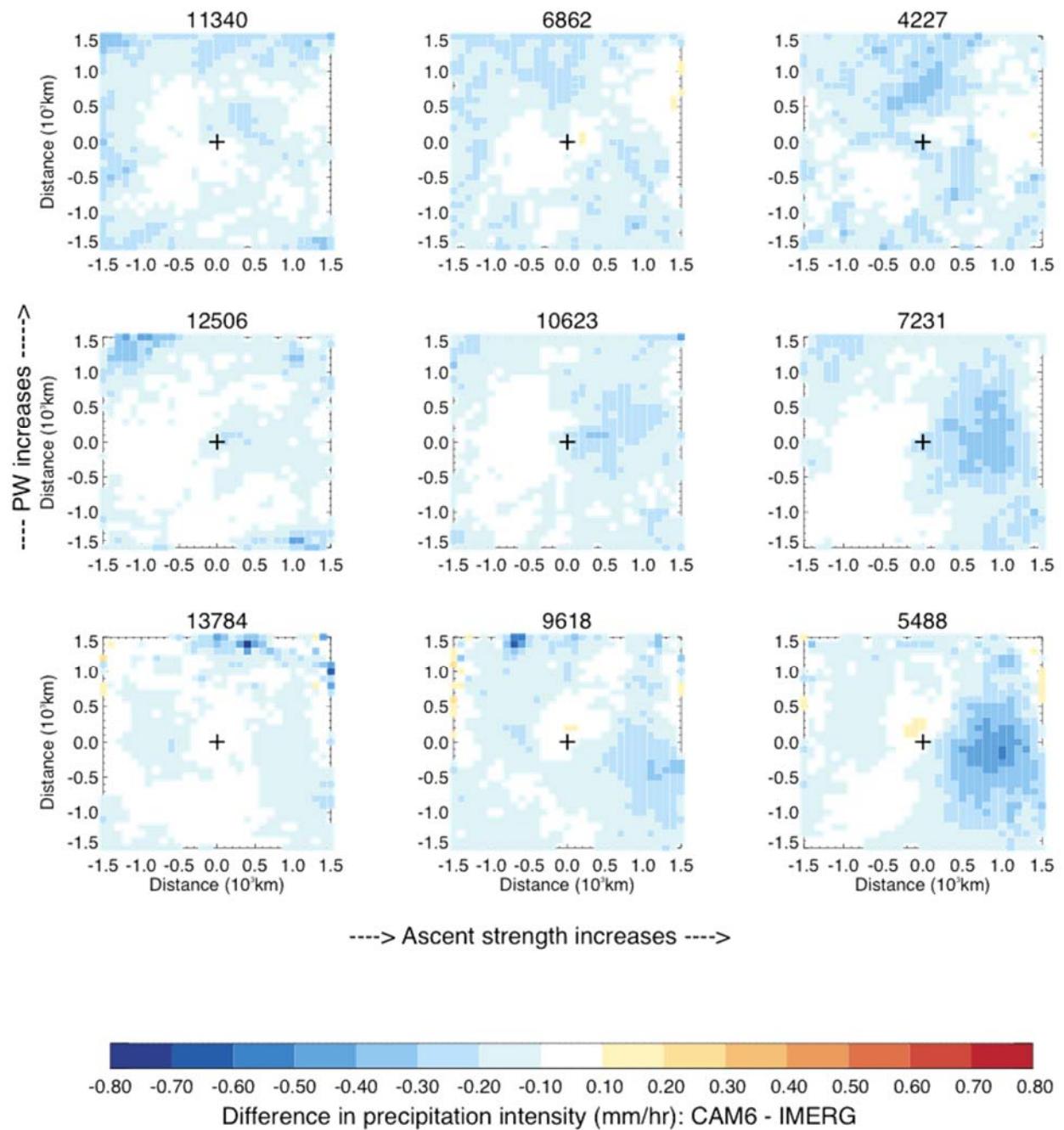


Figure 2: Cyclone centered composites of the difference in mean precipitation between CAM6 and IMERG as a function of cyclone ascent strength (left to right) and cyclone-wide mean PW (bottom to top). The number at the top of each plot is the total number of cyclones per category for CAM6



*Figure 3: Cyclone centered composites of the difference in precipitation intensity between CAM6 and IMERG as a function of cyclone ascent strength (left to right) and cyclone-wide mean PW (bottom to top). The number at the top of each plot is the total number of cyclones per category.*

### 1.3 ERA-interim: total precipitation, frequency and intensity

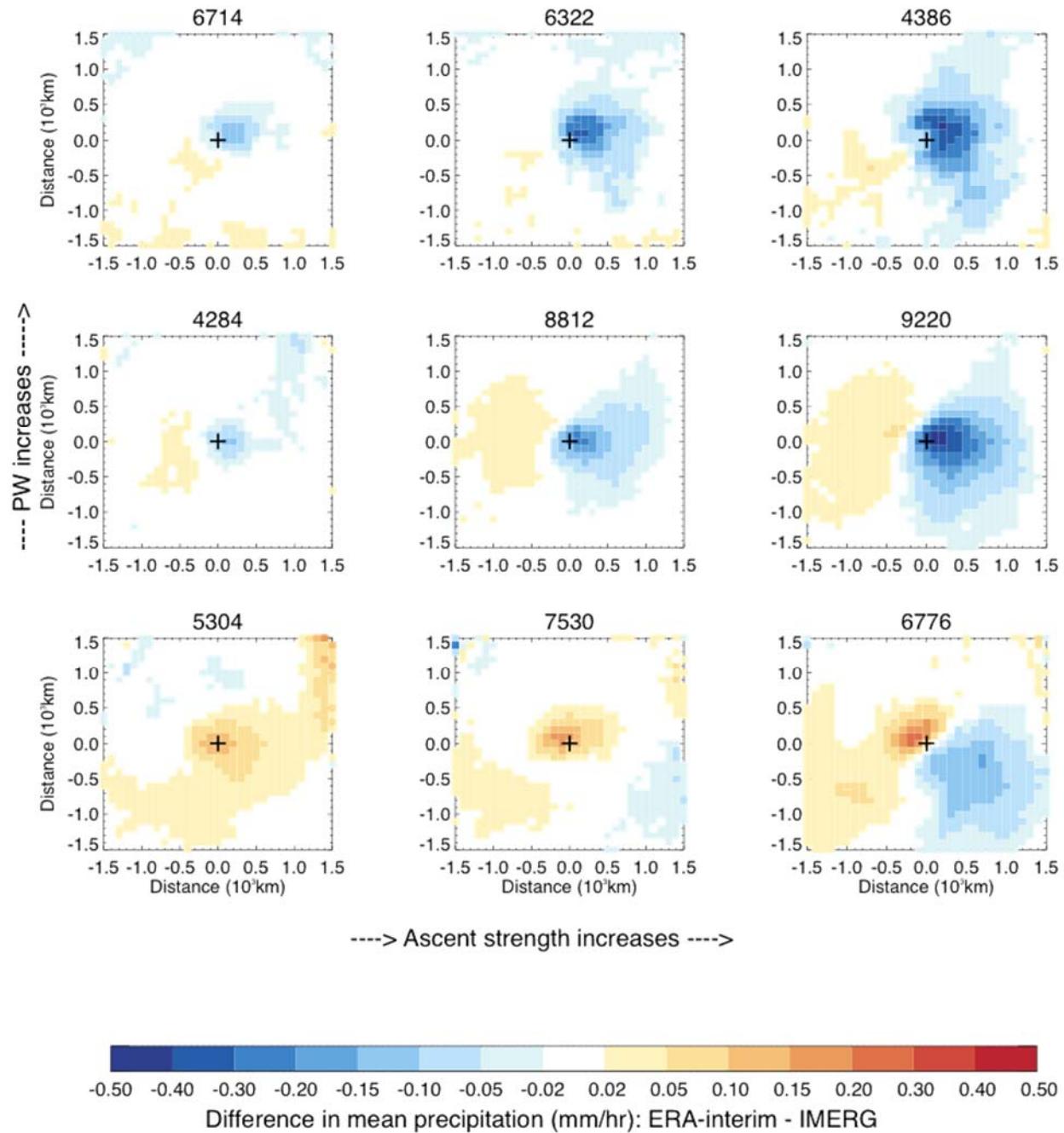
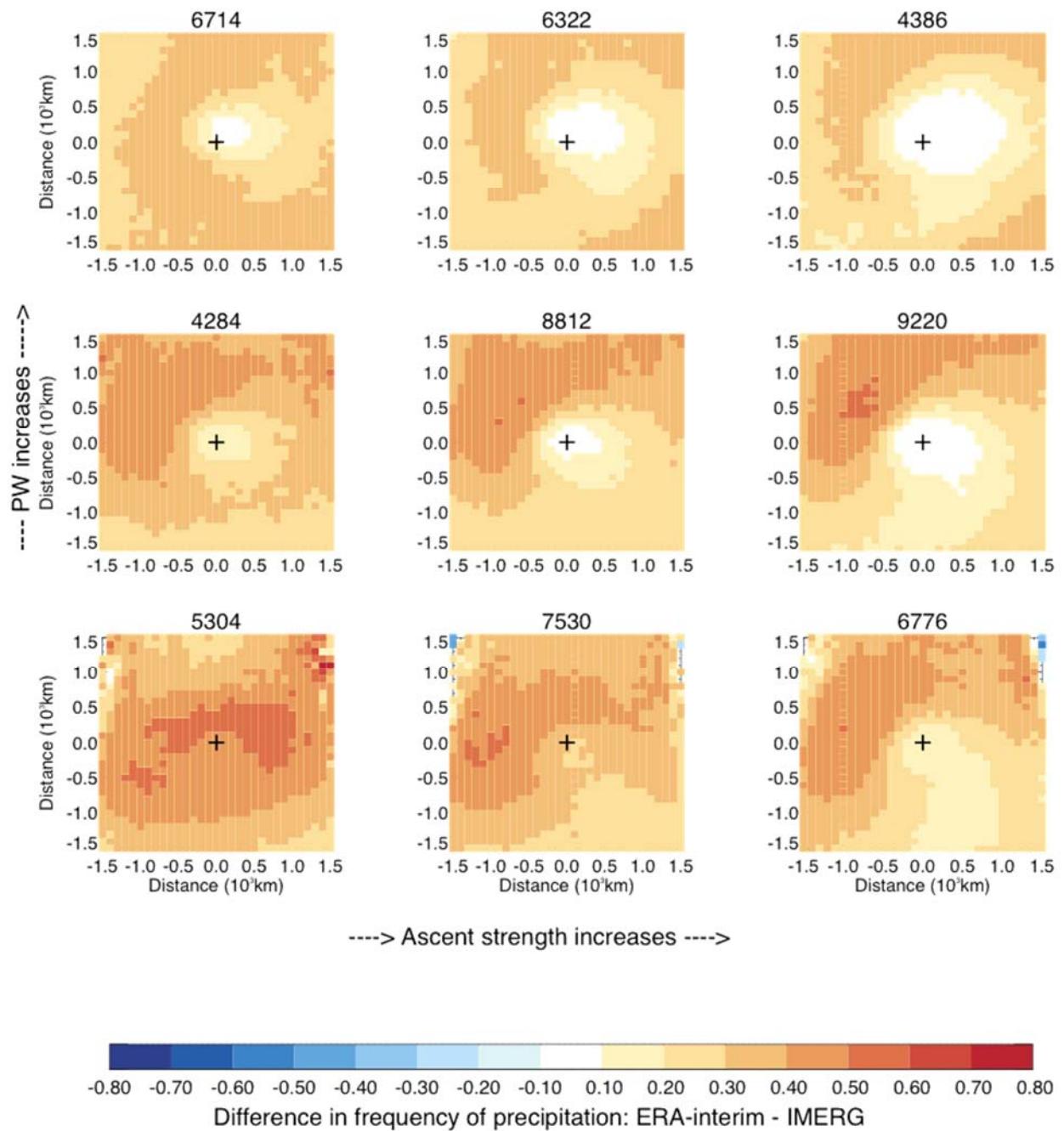
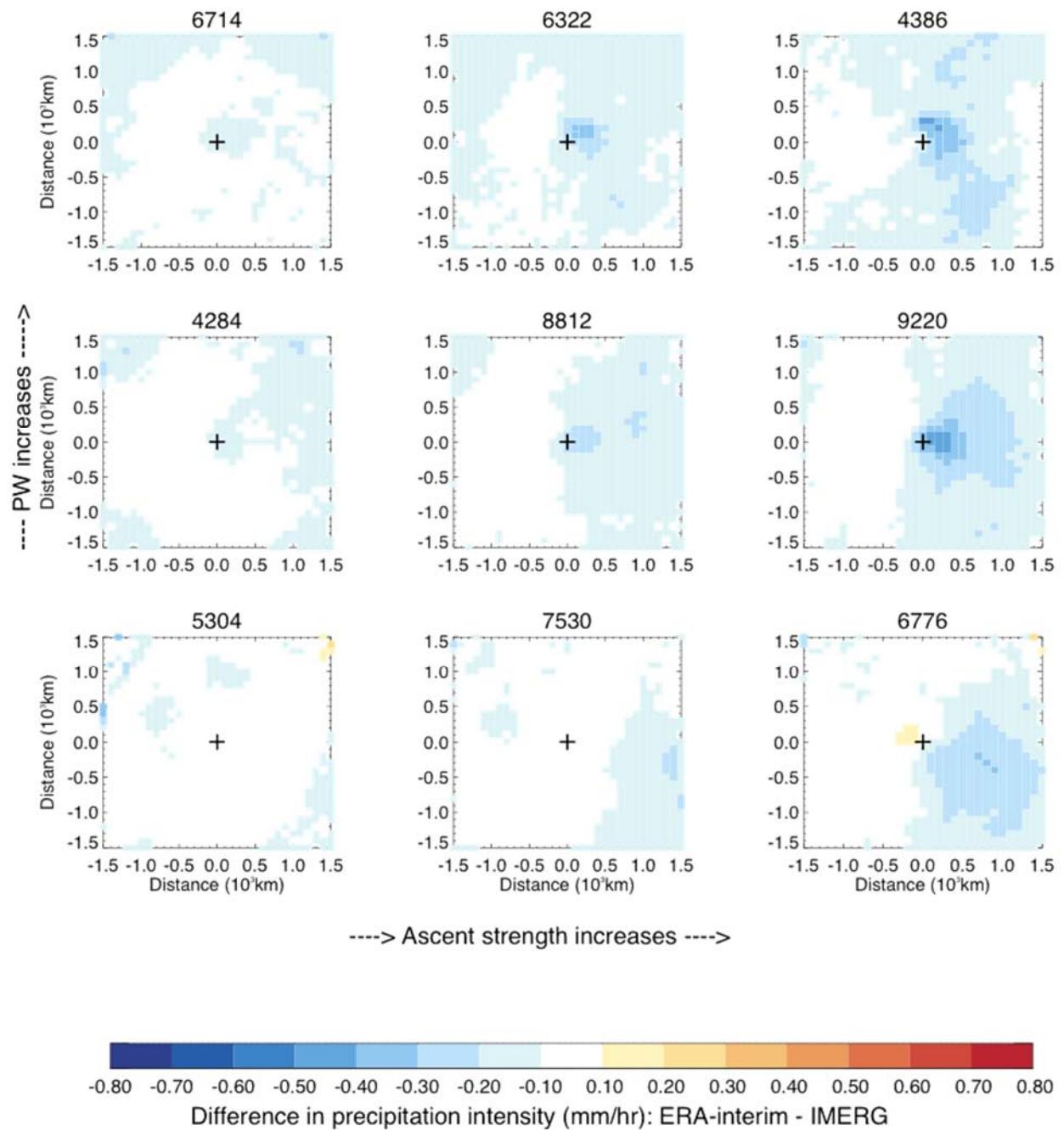


Figure 4: Cyclone centered composites of the difference in mean precipitation between ERA-interim and IMERG as a function of cyclone ascent strength (left to right) and cyclone-wide mean PW (bottom to top). The number at the top of each plot is the total number of cyclones per category for ERA-interim.



*Figure 5: Cyclone centered composites of the difference in frequency of precipitation between ERA-interim and IMERG as a function of cyclone ascent strength (left to right) and cyclone-wide mean PW (bottom to top). The number at the top of each plot is the total number of cyclones per category for ERA-interim.*



*Figure 6: Cyclone centered composites of the difference in intensity between ERA-interim and IMERG as a function of cyclone ascent strength (left to right) and cyclone-wide mean PW (bottom to top). The number at the top of each plot is the total number of cyclones per category for ERA-interim.*

## 1.4 devAM4: total precipitation, frequency and intensity

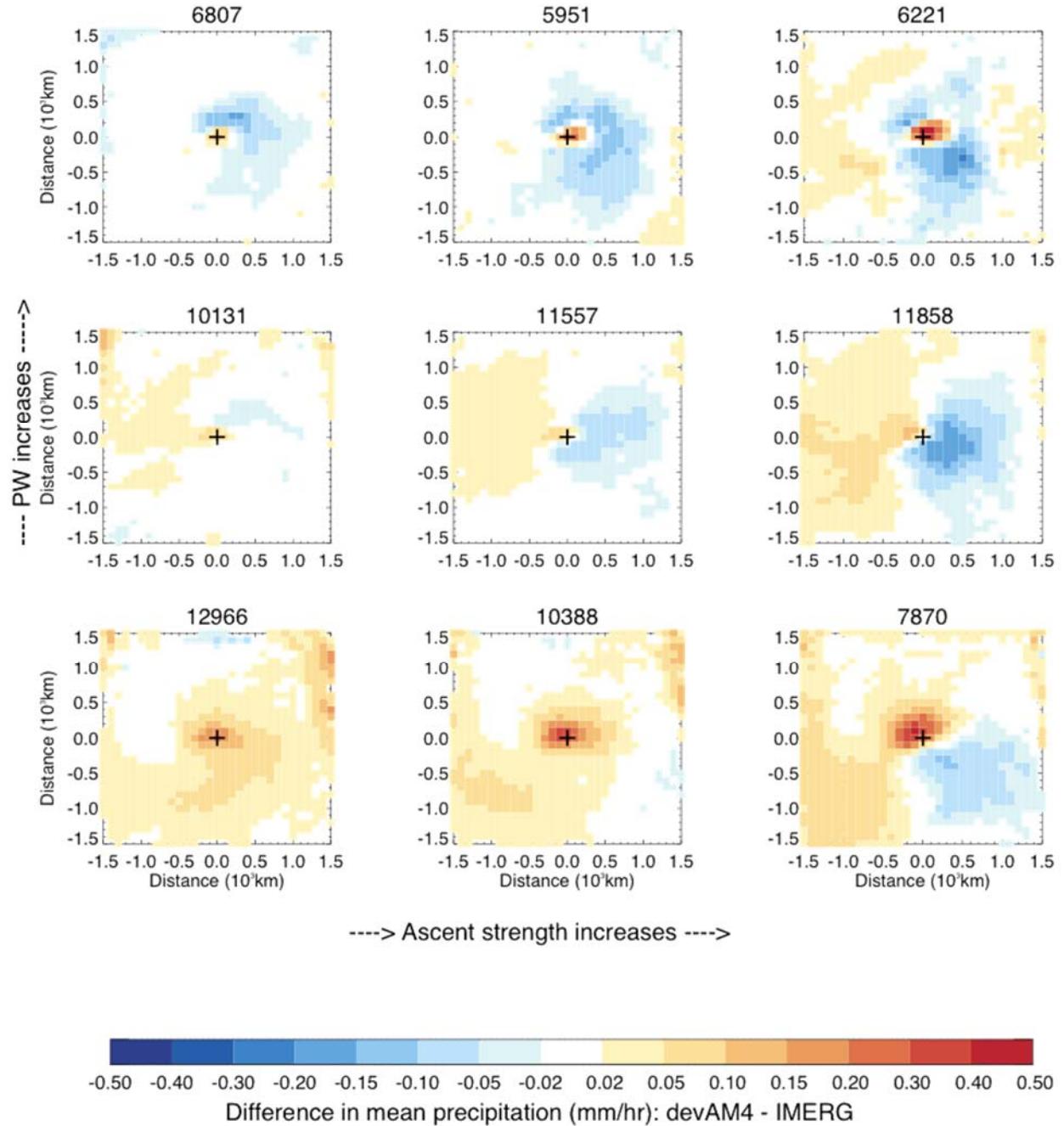
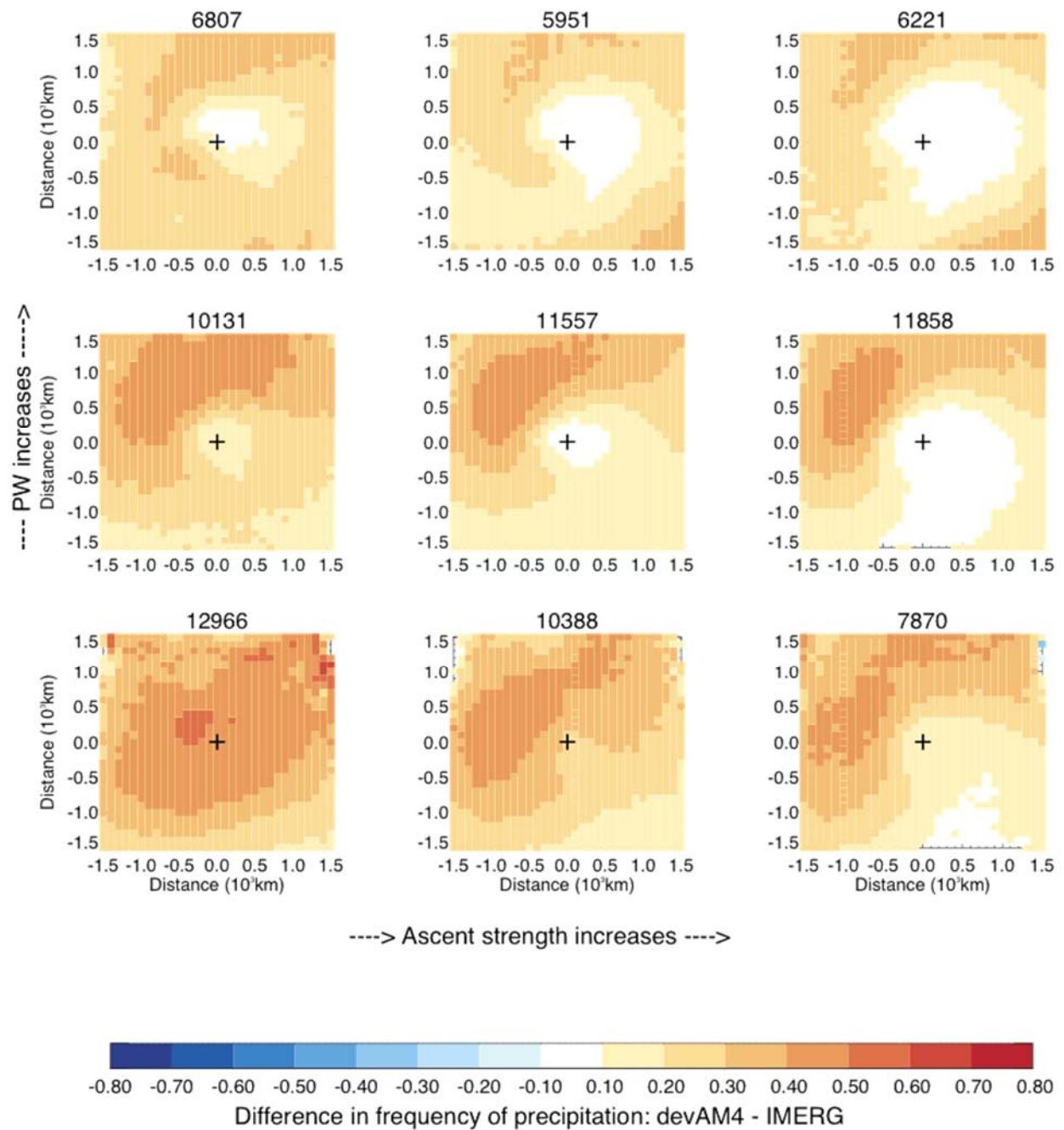
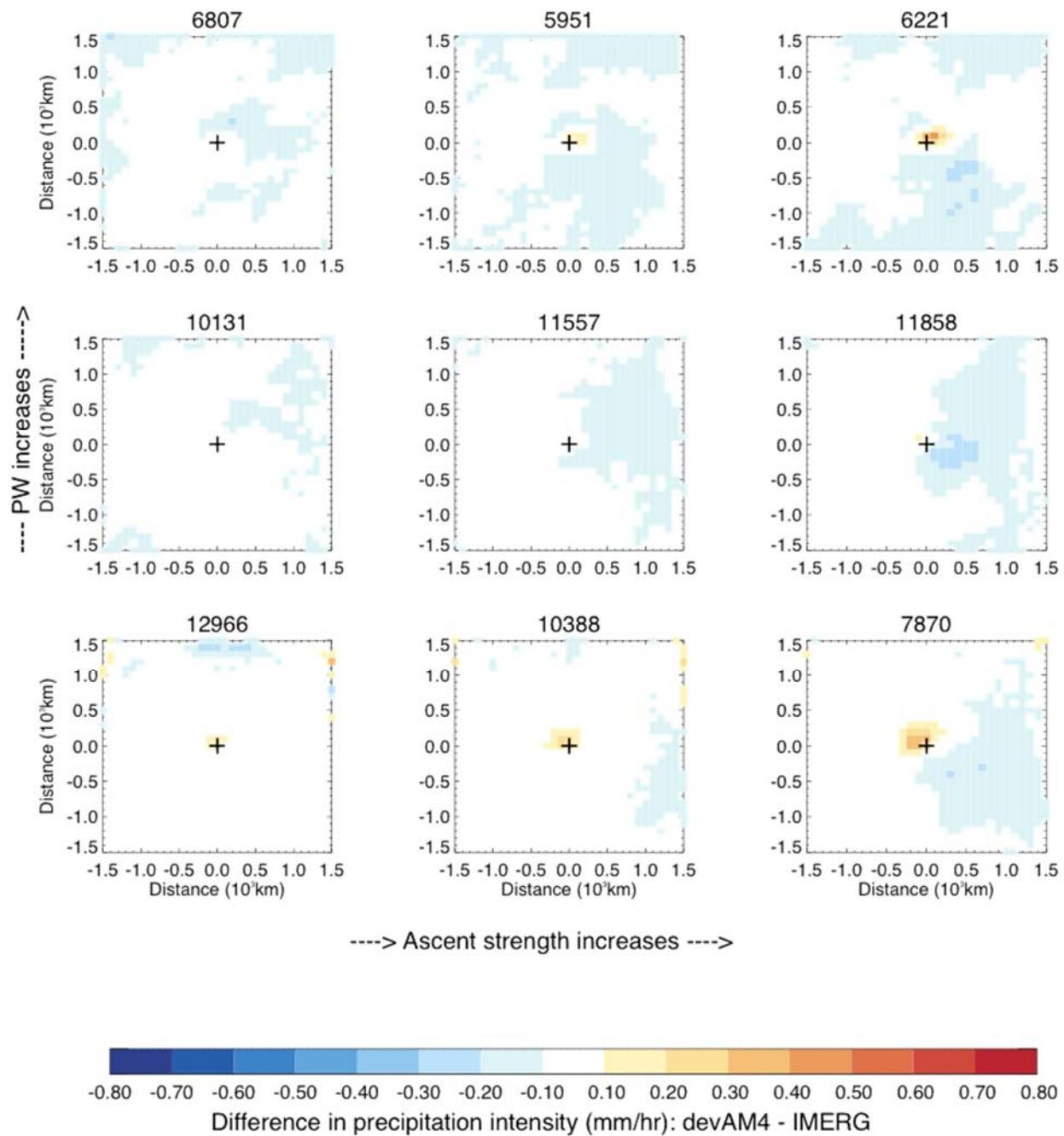


Figure 7: Cyclone centered composites of the difference in mean precipitation between devAM4 and IMERG as a function of cyclone ascent strength (left to right) and cyclone-wide mean PW (bottom to top). The number at the top of each plot is the total number of cyclones per category for devAM4.



*Figure 8: Cyclone centered composites of the difference in frequency of precipitation between devAM4 and IMERG as a function of cyclone ascent strength (left to right) and cyclone-wide mean PW (bottom to top). The number at the top of each plot is the total number of cyclones per category for devAM4.*



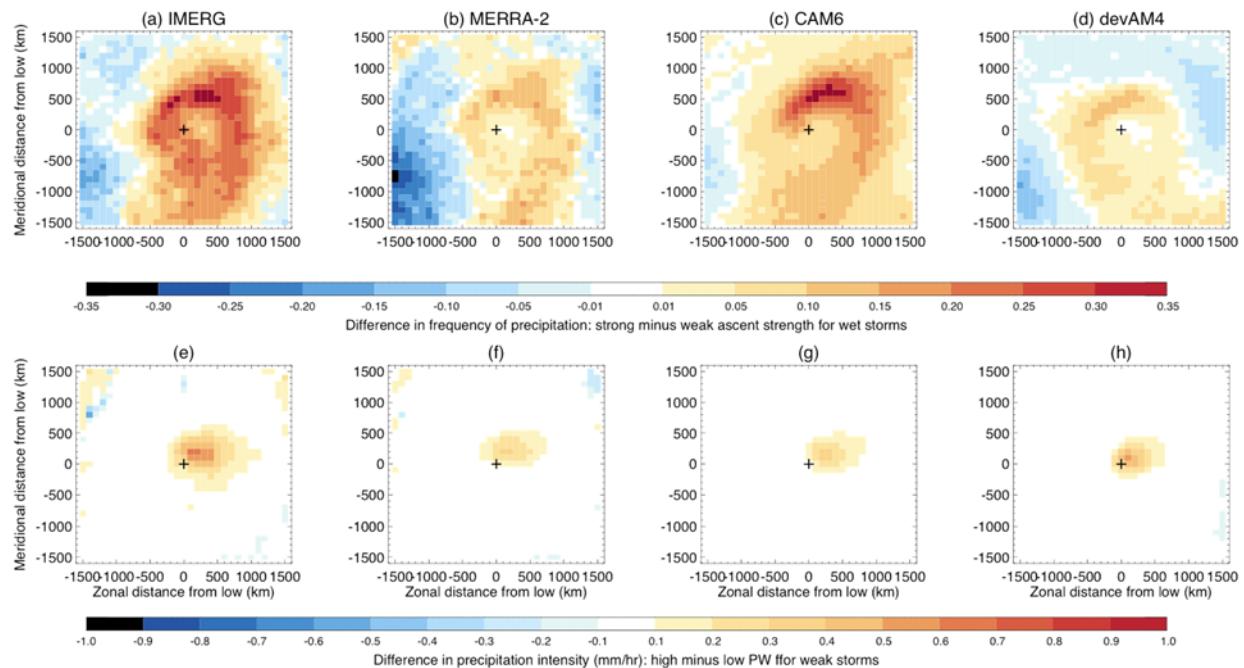
*Figure 9: Cyclone centered composites of the difference in intensity between devAM4 and IMERG as a function of cyclone ascent strength (left to right) and cyclone-wide mean PW (bottom to top). The number at the top of each plot is the total number of cyclones per category for devAM4.*

## 2) Sensitivity to changes in ascent strength or PW

2.1 Subset of wet cyclones for sensitivity to ascent strength and subset of weak cyclones for sensitivity to PW

This figure is meant to verify that the results of Figure 10 are still valid when subsetting the cyclone population: 1) use wet cyclones for the ascent strength test and 2) use weak cyclones for the PW test.

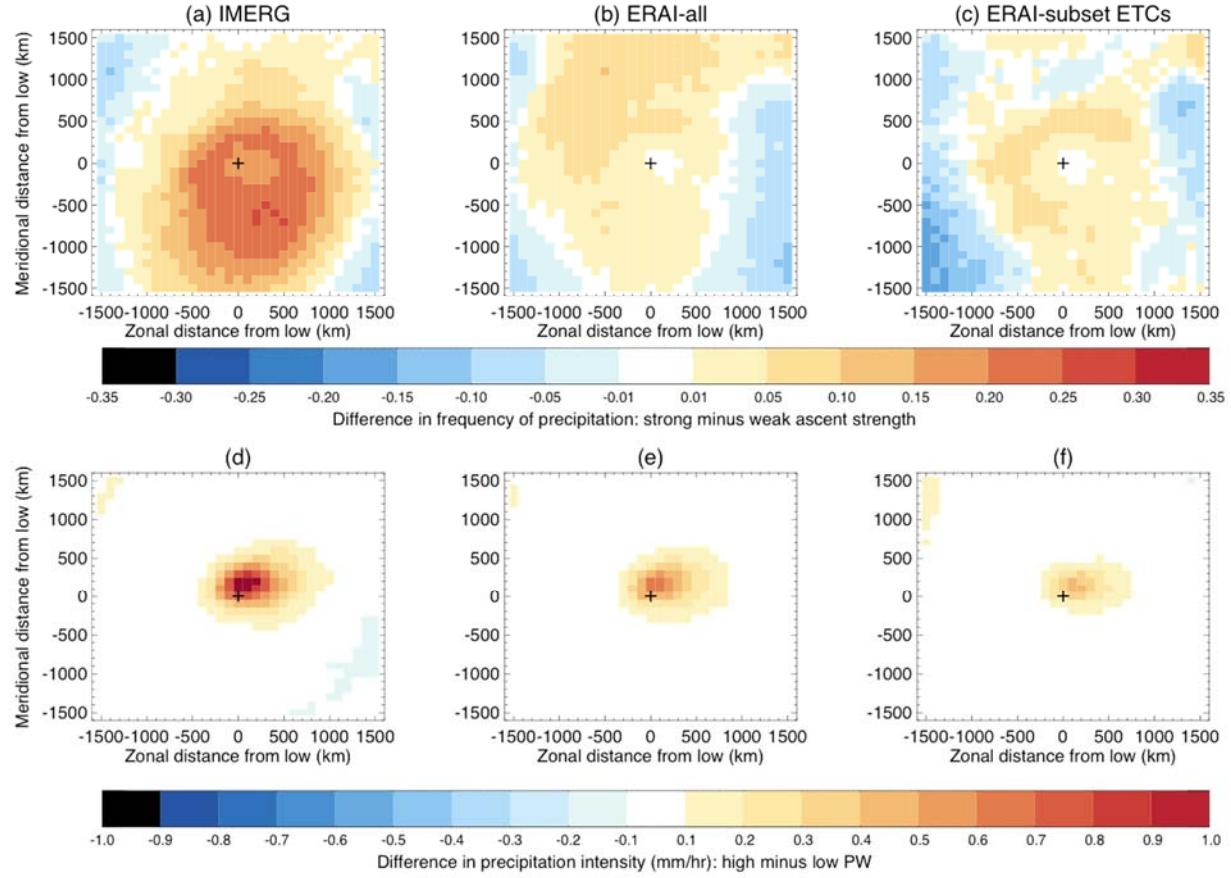
The magnitude of the response changes when subsetting the cyclone population but the inter-model and observations-model differences are qualitatively the same, albeit with larger magnitudes for the wet cyclones, and lower magnitude for the weak cyclones.



*Figure 10: Cyclone centered composite differences in: frequency of precipitation between strong and weak ascent strength PW > 19 mm cyclones for (a) IMERG, (b) MERRA2, (c) CAM6, and (d) devAM4; precipitation rate when precipitating between high and low PW ascent strength > -4.7 hPa/hr cyclones for (e) IMERG, (f) MERRA2, (g) CAM6, and (h) devAM4*

## 2.2 Sensitivities for ERA-interim

This figure includes similar figures as manuscript figure 11 and figure S10 above but for the ERA-interim reanalysis.



*Figure 11: Cyclone centered composite differences in: frequency of precipitation between strong and weak ascent strength cyclones for (a) IMERG when matching ERA-interim, (b) all ERA-interim cyclones and (c) wet cyclones ( $PW > 19 \text{ mm}$ ); precipitation intensity between high and low PW cyclones (a) IMERG when matching ERA-interim, (b) all ERA-interim cyclones and (c) weak cyclones (ascent strength  $> -4.7 \text{ hPa}$ ).*